EFFECTS OF TIMBER HARVEST TREATMENTS ON UNDERSTORY PLANTS AND HERBIVORES IN NORTHEASTERN CALIFORNIA AFTER 40 YEARS

ROBIN S. VORA
University of Idaho, Moscow, ID
Present address: U.S. Forest Service, 318 Forestry Rd.,
Aurora, MN 55705

ABSTRACT

Effects of five timber harvest treatments were evaluated in a pine forest after 40 years. Trends are presented for plant cover, frequency, density, and biomass, as well as on use by three herbivores. Tree growth, mortality, and high natural variability reduced differences among treatments over time. Strongest correlations of understory biomass were with litter, tree dominance, and elevation.

Timber harvesting is widespread in the Pacific Northwest, yet data are lacking on the long-term (>20 years) effects of different timber harvest methods on understory vegetation and subsequent use by herbivores. The purpose of this study was to evaluate the vegetation recovery 40 years after logging in a pine forest in northeastern California.

METHODS

The study area was in Blacks Mtn Experimental Forest, Lassen Co. Approximately half of the study area is in a gently rolling basin; the rest extends up moderate slopes to the north and east. Elevations vary from 1700 to 2100 m. Forest vegetation is characteristic of the Interior Ponderosa Pine type (Eyre 1980) and descriptions specific to the study area are provided in Hallin (1959) and Vora (1988a). Timber volumes (trees larger than 29.5 cm diameter at 1.4 m) were about 105,000 to 116,500 m^3/ha prior to logging (Hallin 1959).

Effects of timber harvest were measured within blocks subjected to six treatments: control (no cutting), 3 levels of partial cutting (removal of 15%, 55% and 75% of timber volume designated as light, moderate, and heavy partial cuts), removal of small groups of trees 29.5 cm diameter and greater (diameter limit cut, about 95% of timber volume), and light partial cutting followed by removal of small groups of trees 10 years later (group selection). The light partial cut consisted of removal of insect-damaged trees. A total of about 30% of the original timber volume was removed in the group selection treatment over a 10 year period (1949–1957). A randomized

MADROÑO, Vol. 40, No. 1, pp. 31–37, 1993

block design was used and 4 to 6 treatments were allocated randomly to 8 ha units within each of 5 blocks. These treatments were initiated 40 years ago for a study of tree growth (Hallin 1959). There were no post-harvest treatments and all regrowth was natural.

To estimate treatment effects, 10 plots were randomly placed along a transect in each treatment unit and the tree density (100 m^2 plots), tree cover and frequency (25 m^2), shrub biomass (9.3 m^2), herbaceous biomass (0.84 m^2), and litter-duff-ground layers were measured as well as droppings of mule deer (*Odocoileus hemionus*), snowshoe hare (*Lepus americana*), and cattle (25 m^2) (Vora 1986, 1988a, b, c). All field work was completed between June of 1983 and August of 1984. Plant nomenclature is according to Munz (1973). Data analyses methods included analyses of variance, multiple comparison tests, correlations, principal components analyses, and stepwise regression (Statistical Analysis System 1982).

RESULTS AND DISCUSSION

Effects on vegetation. Comparisons of effects of timber harvest methods show some trends (Table 1). The density of large trees was higher in the uncut control. Tree basal area, total tree density, and density of small trees were higher in the control and light partial cut. Pole-sized trees were less common in the control. Emphasis on removal of *C. decurrens* in cutting prescriptions (Dunning and Hasel 1938) was probably the reason for significantly more of that species in the control plots. The fewer *Pinus* species trees in the heavier cuts was probably due to replacement by more shade-tolerant *A. concolor*. Reduced fire frequency caused by fire suppression probably helped establishment and survival of *A. concolor* seedlings (Agee et al. 1978).

More snags were observed in the control and lightly cut treatments (light and moderate partial cuts, and group selection). Perhaps, differences among treatments in cavity-nesting birds could be detected.

More small trees were expected in the heavier timber cuts. Instead, more seedlings and saplings were found in the control and light partial cut stands. Treatment means for age of saplings (2.5 to 14.2 cm dbh) were remarkably similar, 48 to 53 years (range of 33 to 100 years). This did not vary with either species or tree diameter. This finding supports the observation by Gordon (1967) that nearly all the young growth on Blacks Mountain pre-dated the original timber harvest treatments (Gordon's estimate of 90 years is much higher than my measured mean of 48 to 53 years). Gordon (1967) suggested that most of the understory probably originated soon after sheep stopped grazing the land and left a good seedbed. Dunston and Wieslander (1933), in their establishment report on the Blacks Mountain Experimental Forest, reported that it was then grazed by 50 head of cattle and 1200 head of sheep between 1 June and 30

September, and the range condition was "good." Conditions after the 1939–1952 timber harvests were apparently not as favorable for natural tree regeneration; seed availability, climatic factors, biotic factors (seed-eating rodents), ground cover, competition by other vegetation (Roy 1983), and possibly soil compaction in skid trails (Vora 1988d) may have combined to be limiting.

Bareground cover and fuel loadings of all size classes were lower in the control and light partial cut. Litter volume estimates were higher in those treatments.

Non-random distribution of understory vegetation and only 3 replications of the light partial cut and diameter-limit cut made trends in variables measuring understory vegetation shown in Table 1 difficult to interpret. Frequencies of *Viola purpurea, Gayophytum humile,* and *Collinsia torreyi* were higher in the heavier cuts (moderate and heavy partial cuts, diameter-limit cut) (Vora 1988a). The frequency of grasses (family Poaceae as a group) was lower in the control and lighter cuts (light partial cuts and group selection).

Overstory, litter, and environmental variables correlated with shrub, twig, forb, and grass biomass (Table 1). The strongest correlations ($P < 0.001$) with understory biomass were litter, total tree cover, bareground cover, total tree density, number of small trees (2.5 to 27.7 cm dbh), *Abies concolor* dominance (canopy cover, densities by size classes, basal area), and elevation. Principal Components Analyses did not contribute to data reduction for the purpose of determining overstory-understory relationships. When run with 21 variables, for example, sixteen components were needed to describe 95% of the variance. Litter cover or volume was usually the first term in descriptive equations predicting understory biomass derived by stepwise regression. These equations, derived under the assumption of cause and effect (Ffolliot and Clary 1972 and others), explained 14 to 48% of the variance in microplots and 50–96% of the variance in treatment unit means (Vora 1986).

Tree growth and high insect-caused mortality (Hallin 1959; Hart 1983) reduced differences in treatment effects on understory over time. Gap openings in old-growth control stands caused by insect mortality and, formerly, natural fire, created a mosaic of small, even-aged clumps of trees of a variety of age classes. Such natural heterogeneity probably existed 40 years ago when treatments were applied, thereby making determination of treatment effects difficult. Results were statistically non-significant ($P > 0.05$) because of high variability and small sample sizes (5 blocks or replications).

Effects on herbivores. Snowshoe hare droppings were correlated positively with litter and tree variables, negatively with bareground cover, but not with any variables measuring understory biomass. Snowshoe hares prefer dense forests (Bittner and Rongstad 1982).

TABLE 1. COMPARISON OF EFFECTS OF TIMBER HARVEST METHODS AFTER 40 YEARS. [1] Numbers followed by the same or no letter were not significantly different ($P < 0.05$). [2] Measured with a spherical densiometer. [3] Nonparametric ANOVA. [4] ln transformation.

	Treatment						
		Light partial cut (15%)					
Variable	Control (No cutting)	No further treatment	Trees removed 10 yr later	Moderate partial cut (55%)	Heavy partial cut (75%)	Cut >29.5 cm diameter	ANOVA (P)
Trees							
Tree canopy cover (%)[2]	55	57	43	45	50	51	0.48
Tree basal area (m³ ha)	27	29	20	21	22	18	0.09
Total trees per ha	2802	3020	2090	1772	2522	1730	0.64[3]
Large trees per ha (>63.4 cm dbh)	34	14	4	14	14	8	0.01[1]
Pole trees per ha (14.3–27.7 cm dbh)	214c	454ab	284abc	244bc	388ab	304abc	0.05
Small trees per ha (2.5–14.2 cm dbh)	2484	2396	1684	1430	2043	1243	0.09[3]
Pinus spp. trees per ha	1878	1920	1348	1166	1308	533	0.83
Calocedrus decurrens trees per ha	460	173	196	158	254	170	0.06[3]
C. decurrens canopy cover (%)	7a	1b	2b	2b	4ab	1b	0.04
Abies concolor trees per ha	464	913	546	448	960	1013	0.12
Ground							
Total fuels (tonne/ha)	16ab	7b	28a	28a	26a	31a	0.02[3]
Litter volume (m³ ha)	272a	336a	176ab	100b	212a	164ab	0.05[4]
Bareground cover (%)	2b	<1b	6ab	6ab	4b	10a	0.05
Shrubs							
Ceanothus prostratus frequency (%)	68a	70a	78a	68a	54ab	17b	0.02
C. prostratus cover (%)	16	18	17	17	13	2	0.20
Arctostaphylos patula frequency (%)	26b	28ab	52a	40ab	34ab	18b	0.02
A. patula biomass (kg/ha)	253	6	411	141	184	10	0.10
Purshia tridentata (kg/ha)	252	243	181	237	215	571	0.60
Artemisia tridentata (kg/ha)	<1	<1	96	95	151	732	0.38

TABLE 1. CONTINUED.

Variable	Treatment						ANOVA (P)
		Light partial cut (15%)					
	Control (No cutting)	No further treatment	Trees removed 10 yr later	Moderate partial cut (55%)	Heavy partial cut (75%)	Cut >29.5 cm diameter	
Forbs							
Viola purpurea frequency (%)	16	16	12	24	24	20	0.25
Gayophytum humile frequency (%)	6	0	8	14	10	33	0.03
Collinsia torreyi frequency (%)	18	13	30	32	30	40	0.49
Grasses							
Family Poaceae frequency (%)	70	76	76	89	92	94	0.14
Herbivores (cumulative droppings per ha)							
Deer	168ab	107b	216ab	160ab	104b	280a	0.02
Recent deer (Summer 1983)	8	13	24	8	8	13	0.81
Snowshoe hare	448	506	376	136	280	320	0.51
Cow	48	65	24	80	16	92	0.62

Mule deer populations were too low to allow analysis of effects of treatments, and the 8-ha treatment units were probably too small. Frequency of droppings in 25-m^2 subplots was 20% for mule deer, 35% for snowshoe hare, and 10% for cattle. Animal presence was probably also influenced by factors such as water, predation, and disturbance that were not controlled in this experiment. Both deer and cattle were most common in the vicinity of sagebrush meadows and water. Cattle were not found at higher elevations. *Purshia tridentata,* a favored browse species (Leach 1952) was common at the lower elevation meadow edges (Vora 1988a).

Acknowledgments

I thank J. Peek, E. Garton, F. Johnson, M. Hironaka, D. Everson, P. Mika, J. Norris, R. Brewster, K. Falke, R. Laacke, D. Neal, J. Kie, J. Verner, W. Laudenslayer, J. Keeley, R. Powers, D. Roy, P. McDonald, H. Biswell, D. Gordon, S. Larson, D. Airola, K. Estes, K. Toor, D. Owens, K. Jenkins, B. Griffith, B. Youtie, M. Prouty, G. Frasier, and N. Wells for their assistance with this study and manuscript.

Literature Cited

AGEE, J. K., R. H. WAKIMOTO, and H. H. BISWELL. 1978. Fire and fuel dynamics of Sierra Nevada conifers. Forest Ecology and Management 1:255–265.

BITTNER, S. L. and O. J. RONGSTAD. 1982. Snowshoe hare and allies. Pp. 146–163 *in* J. A. Chapman and G. A. Feldhamer (eds.), Wild mammals of North America, biology, management, and economics. John Hopkins University Press, Baltimore, MD.

DUNSTON, C. E. and A. E. WIESLANDER. 1933. Report on Blacks Mountain Experimental Forest, Lassen National Forest, California. Unpublished. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Redding, CA.

DUNNING, D. and A. A. HASEL. 1938. The Blacks Mountain Experimental Forest, a sustained yield experiment in ponderosa pine in northeastern California. Unpublished. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Redding, CA.

EYRE, F. H. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC.

FFOLLIOT, P. F. and W. P. CLARY. 1982. Understory-overstory vegetation relationships: an annotated bibliography. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-136.

GORDON, D. T. 1967. Prescribed burning in the interior ponderosa pine type of northeastern California, a preliminary study. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Paper PSW-45.

HALLIN, W. E. 1959. The application of unit area control in the management of ponderosa-Jeffrey pine at Blacks Mountain Experimental Forest. USDA Forest Service, Washington, DC, Technical Bulletin 1191.

HART, D. 1983. Tree mortality on the method-of-cutting treatment plots at Blacks Mountain Experimental Forest for the years 1980 through 1981. Unpublished. USDA Forest Service Region 5, Forest Pest Management Staff.

LEACH, H. R. 1952. Food habits of the Great Basin deer herds of California. California Fish and Game 42:243–328.

MUNZ, P. A. 1973. A California flora and supplement. University of California Press, Berkeley.

ROY, D. F. 1983. Natural regeneration. Pp. 87–102 *in* T. F. Robson and R. B. Standiford (eds.), Management of the eastside pine type in northeastern California, proceedings of a symposium. Northern California Society American Foresters, SAF 83-06, Arcata, CA.

Statistical Analysis System. 1982. SAS user's guide: statistics, 3rd ed. SAS Institute Inc., Cary, NC.

Vora, R. S. 1988a. Species frequency in relation to timber harvest methods and elevation in the pine type of northeastern California. Madroño 35:150–158.

———. 1988b. A comparison of the spherical densiometer and ocular method to estimate canopy cover. Great Basin Naturalist 48:224–227.

———. 1988c. Predicting biomass of five shrub species in northeastern California. Journal Range Management 41:63–65.

———. 1988d. Potential soil compaction forty years after logging in northeastern California. Great Basin Naturalist 48:117–120.

———. 1986. Effects of timber harvesting in northeastern California on understory species composition, density, and production, and on use by mule deer, cattle, and snowshoe hare. M.S. thesis. Univ. of Idaho, Moscow.

(Received 13 Jan 1992; revision accepted 8 Jul 1992.)

ANNOUNCEMENT

The 1992 Jesse M. Greenman Award

The 1992 Jesse M. Greenman Award has been won by Sharon Elaine Bartholomew-Began for her publication "A morphogenetic re-evaluation of *Haplomitrium* Nees (Hepatophyta)", published as Volume 41 of Bryophytarum Bibliotheca. This study is based on a Ph.D. dissertation from Southern Illinois University at Carbondale, under the direction of Dr. Barbara Crandall-Stotler.

The Greenman Award, a certificate and a cash prize of $500 is presented each year by the Missouri Botanical Garden. It recognizes the paper judged best in vascular plant or bryophyte systematics based on a doctoral dissertation published during the previous year. Papers published during 1992 are now being accepted for the 25th annual award, which will be presented in the summer of 1993. Reprints of such papers should be sent to Dr. P. Mick Richardson, Greenman Award Committee, Missouri Botanical Garden, P.O. Box 299, St. Louis, Missouri 63166-0299, USA. In order to be considered for the 1993 award, reprints must be received by 1 June 1993.